

ONR Partnering in Research to Battle Ghana's Eroding Coastline

Office Upholds Navy's Strategic & Humanitarian Focus

DESPITE THE TROPICAL temperatures, the beach at Ada Foah on the eastern coast of Ghana is much like the tip of an iceberg. As anyone knows, most of the ice in an iceberg is hidden below the surface. Similarly, for Ghana, the real story of coastal erosion is not about what lies at the water's edge, but what occurs beneath the waves offshore. The Office of Naval Research (ONR) is hard at work, investing and partnering in research that could lessen or even stop the

capital city of Accra, an estimated 70 percent of the beach is eroding at rates exceeding three feet per year.

Ghanaian scientists and students attending the University of Ghana are working with investigators from the Coastal Geosciences Program at ONR to expose the hidden workings of Ghana's largely unexplored nearshore environment. The new research effort, under the support of the U.S. Navy's Africa Partnership Station (APS), has two goals:

research? "This research is key to helping Ghana protect and sustain the ecology and economic vitality of its coastline. This investment underscores the Navy's commitment to the humanitarian and partnerships elements of The National Maritime Strategy, which is about opportunities, optimism and confidence in uncertain times," said then-Deputy Assistant Secretary of the Navy for the Environment, Donald Schregardus.

ONR's sponsorship of this research provides a mutual benefit for us and our West African partners.

—Donald Schregardus, then-Deputy Assistant Secretary of the Navy

impacts of Ghana's eroding coastline such as loss of structures, human life and economic well-being.

A tremendous amount of sand lays just offshore many beaches, as invisible as the bulk of an iceberg—until the supply of sand is disrupted and the shoreline begins to disappear. A small fishing village near the mouth of the Volta River, Ada Foah is only one of many beaches on the coast of Ghana that are slowly eroding—in the

1. Accelerate the introduction of scientific tools to Ghanaian scientists to improve their ability to observe and govern coastal waters, and
2. Establish a self-sustaining educational program to train coastal oceanographers in maritime technologies.

Why are the Navy and the Department of Defense interested in pursuing Ghanaian oceanographic

The Navy's interest in West African countries was sparked by adoption of innovative approaches to regional policy by the new U.S. African Command (AFRICOM), established in 2008. Unlike traditional unified commands, AFRICOM will focus on building African regional security by leveraging existing non-governmental organizations' relationships with African governments.

APS is a key component of the Navy's role in AFRICOM, and employs ship

visits to African ports to conduct joint exercises and provide hands-on practical courses in maritime safety and security, among other programs. APS deployed the HSV-2 SWIFT to several West African countries in spring 2008; a follow-up deployment of the USS NASHVILLE was underway in spring 2009.

Schregardus went on to say, “ONR’s sponsorship of this research provides a mutual benefit for us and our West African partners. This technology promises to improve the ability to monitor coastal zones, manage fisheries and reduce environmental damage resulting from illegal activities such as over-fishing and coral harvesting.”

Dr. George Wiafe, a biological oceanographer from the University of Ghana, is one of several driving forces behind the coastal program’s rapid progress. At the behest of Dr. John Mittleman, then science advisor to U.S. Naval Forces Europe-U.S. Naval Forces Africa/U.S. 6th Fleet and Dr. Melanie Jarvis, from the U.S. Navy’s Space and Naval Warfare Systems Center, Dr. Wiafe and several West African scientists were invited to meet with ONR scientists in Barcelona, Spain to discuss research interests. Dr. Wiafe, head of the Department of Oceanography and Fisheries at the University of Ghana, delivered a short lecture to ONR scientists on the rewards and difficulties of doing scientific research in West Africa. In return,



Typical local fishing vessel “The Ghana Boat” launched manually off the beach and used extensively for fishing in Ghana.

Dano Roelvink





Fishing boat's precarious position illustrating rapid erosion, a serious problem widespread in the Cape Coast region.

Dano Roelvink

International research collaborator collecting real-time ground penetrating radar data to reveal the underlying geology at Mukwe Beach near Accra.

Cheryl Hapke



Wiafe was invited to write a proposal to ONR to bring his scientific and educational aspirations to life.

With APS as the backdrop for the Ghana research effort, the pieces of the research puzzle rapidly came together under the leadership of Dr. Augustus Vogel, the Maritime Partner Liaison for U.S. Naval Forces Europe. Dr. Wiafe's team in Ghana was matched with ONR investigators who could bring years of research expertise to bear on a range of

coastal issues. Joining Vogel on the first APS deployment were Dr. Tom Lippmann from the University of New Hampshire and Dr. Dano Roelvink from the United Nations Educational, Scientific and Cultural Organization—International Institute for Hydraulic and Environmental Engineering for Water Education in Delft, The Netherlands. Lippmann is an expert in the field measurement of beach processes and is one of the developers of shore-based video observations of waves. Roelvink is an

expert in computer modeling and prediction of nearshore processes. Lippmann and Roelvink brought their skills to the University of Ghana and soon had a crew of beach-savvy students and faculty eagerly measuring the slopes and other properties of beaches near the capital of Accra and feeding it into state-of-the-art open-source computer models for beach change authored by Roelvink. Nightly strategy sessions mapped out a plan to bring new techniques and technologies to Ghana to incrementally build the University's nascent coastal oceanography program.

A great deal of discussion was needed to shape the coastal research questions into a suitable plan. A key initial goal suggested by ONR officials, for example, was the introduction of satellite remote sensing techniques to provide a continuous picture of shipping and fishing off of the Ghanaian coast. At present, only vessels within eyesight of the shoreline can be counted—leaving Ghana's productive coastal fisheries at the mercy of illegal fishing boats from other countries. ONR is a world-leading developer of remote sensing capabilities for maritime governance and oceanographic observations—an obvious top priority for international exchange among researchers. Dr. Hans Graber, director of the Center for Southeastern Tropical Advanced Remote Sensing (CSTARS) at the University of Miami and a long-time ONR researcher came to the table with suggestions for remote sensing collaborations, but discussion quickly exposed a significant roadblock: moving bulky satellite image data from satellite ground stations to Ghana for analysis requires a high-data-rate internet connection. As Wiafe explained, "We have access

to the internet, but our connection is rather poor—we usually send email only in the early morning or late in the evening to avoid the traffic.” In fact, the connection for the entire university community of about 40,000 students and faculty is slower than that in a single typical U.S. household.

With the long-term remote sensing goals still firmly in mind, the Ghana-ONR team decided to exploit available aerial photos and coastal imagery to determine trends in coastal erosion as a first step and guide to focusing the University’s new nearshore observational skills. The second APS deployment of the USS NASHVILLE in spring 2009 brought two new ONR researchers into the team. Dr. Cheryl Hapke from the U.S. Geological Survey, an expert in analysis of historical aerial photographs of the coast, was paired with Dr. Andrew Ashton, a coastal geomorphologist from the Woods Hole Oceanographic Institution (WHOI), to bring a historical and geological component to the effort. Hapke brought Geographic Information Systems software for installation on workstations at the University, and demonstrated how to extract coastal erosion rates from aerial photographs. Such analysis will reveal erosion hotspots and guide the deployment of instrumentation that will in turn be used to predict future beach response.

Ashton brings a geologist’s long-term perspective to the problem of local beach evolution. Ashton’s research emphasizes the importance of the underlying and adjacent geology in determining the fate of Gulf of Guinea beaches. On a field trip to areas near the mouth of the Volta River, he demonstrated the use of ground-penetrating radar to map the underlying rock structure as well as ancient delta deposits. The Volta River, dammed in the early 1960’s, created a huge lake that covers nearly four percent of Ghana. While providing hydroelectric power and irrigation water, the dam also traps the sediment that formerly nourished beaches adjacent to its mouth. The effect of disrupting the supply of sediment to

beaches may take decades to fully manifest itself in the form of beach erosion, and the framework of historical aerial photographic and geological analysis presented by Hapke and Ashton will provide a basis for future coastal development and mitigation issues.

Two key components of successful introduction of new research capabilities and technologies are persistence and self-sustainment, and a major emphasis of Vogel’s work with APS is the development of a lasting foundation for continued development. As the only program participant with experience in West Africa, Vogel has repeatedly emphasized the pitfalls of short-term relationships among U.S. researchers and those in other

Scarp and undercut asphalt indicating high rates of erosion at Ada Foah beach, Eastern Ghana.
Cheryl Hapke





As a result of extensive erosion, tombstones and graves are being washed away at an abandoned town near Ada Foah.

Cheryl Hapke



Rapid beach erosion resulting in destruction of the principal coastal road east of the Volta River mouth.

Dano Roelvink

countries. The ONR core team is one part of a much larger collaborative program that has connections to U.S. Department of State and various non-governmental organizations. Ghanaian government agencies including the Ghana Environmental Protection Agency and the Ghana Geological Survey have joined the original University of

Ghana participants from the Department of Oceanography and Fisheries and most recently the Department of Geography.

Growing Ghanaian maritime governance capabilities into the future requires a commitment to training students in Ghana who will then transfer their knowledge to the next

generation of researchers. A host of researchers and students led by Dr. Wiafe are forging international ties that bode well for the program's future: Mr. Selorm Ababio, one of Dr. Wiafe's graduate students, visited WHOI on a WHOI fellowship in summer 2009. Dr. Wiafe will be visiting the U.S. through the Department of State's International Visitors Leadership Program. Another graduate student, Mr. Kwame Adu Agyekum will be joining a research cruise of the tropical Atlantic, headed by Dr. William Johns of the Rosenstiel School for Marine and Atmospheric Research at the University of Miami. Agyekum presented original research at the International Geoscience & Remote Sensing Symposium in July 2009, and then proceeded to the U.S. for several months to train on a variety of computer programs for analysis of satellite imagery.

Lippmann returned to Ghana in August 2009 to continue working with the Ghanaians; one key task was to plan for the deployment of a newly acquired wave buoy, which will provide the measurements of wave height and direction needed for coastal erosion predictions. The vast fleet of artisanal fishing boats may solve one of the remaining problems, that is, making measurements of the seafloor shape or bathymetry needed for effective predictions. Rather than relying on custom surveying vessels that can cost tens of thousands of dollars per day, the ONR researchers have devised inexpensive echosounders that can be mounted to fishing boats, which can then make continuous depth measurements during their coastal fishing excursions. Although the measurements will lack the complete coverage provided by a survey vessel,

University of Ghana field crew and international collaborators ferrying Global Positioning System and ground penetrating radar equipment across a coastal river mouth ahead of the incoming tide at Mukwe Beach.

Cheryl Hapke



University of Ghana students removing frame and pump from the surf zone after installing instruments to measure nearshore waves and currents.

Dano Roelvink



they are perfectly suited for making progress in the right direction. The ONR and APS program started with small achievable goals, but still has its eye on the prize—the in-house capability to remotely sense Ghana’s maritime environment. Only recently have large oil deposits been discovered in the seafloor offshore Ghana, further bolstering the need for the tools to effectively govern the country’s ocean resources. 

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